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Research Article

Optimum Configuration of Solar PV Topologies for DC Microgrid Connected to the Longhouse Communities in Sarawak, Malaysia

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In the past few years, the prime focus of supplying electricity to the longhouse communities in the rural areas of Sarawak has been initiated based on the utilization of a single-source microgrid configuration. The existing AC power supply-based solar photovoltaic (PV) systems in these areas pose many problems, mainly owing to the stages of conversion, energy losses, and the quality of power transfer. As the solar PV system is a DC source and most of the appliances in longhouse communities could be operated using DC source, an opportunity to design a microgrid with high reliability and efficiency would be achieved by the implementation of an optimal DC microgrid configuration. With this aim, the paper proposes a multiple-source DC microgrid configuration for the longhouse communities in Sarawak. Initially, a framework has been developed to design simulation models for both microgrid configurations (single and multiple sources) using MATLAB Simulink. The configuration of each system consists of a solar PV and energy storage to form a standalone microgrid. Due to the change in system configuration of DC microgrid, in the modeling approach, the standard power flow equations are modified to include solely the DC parameters. To validate the proposed configuration with the associated modeling approach in terms of the power flow reliability, system efficiency, and power-voltage curve, an experimental setup representing the Simulink model has been designed for each standalone microgrid configuration. The configurations have been assessed in the same location with different daily weather conditions. The obtained simulation and experimental results confirm that the proposed configuration of multiple sources is more reliable and efficient than the existing single-source configuration.

1. Introduction

In Sarawak, the widely used renewable energy sources (RESs) to supply the consumers in the remote areas are the solar PV systems and small hydropower generators. It is reported in [1] that 80% of Malaysians prefer using solar energy as the main source of electricity, whereas 84% believe that the most suitable source in Malaysia is solar energy. This indicates a higher demand for solar PV systems as compared to other types of renewable energy systems. Hence, new approaches should be developed to maximize the usage of energy from renewable resources [2]. This section sheds the light on the electricity coverage in Sarawak and reviews the research work carried out on the DC microgrids. The contribution and paper organization with the schematic overview are also presented in this section.

1.1. Motivation. The state of Sarawak has the lowest electricity coverage in the rural areas as compared to other states in Malaysia. Due to the variable tropical climate in Sarawak, maintaining a reliable power supply is one of the main concerns in the existing AC microgrid-based PV systems. According to the statistics provided by the Ministry of Public Utilities, in 2010, the percentage of electrified houses in the rural areas of Sarawak was approximately 78%. This implies that a large number of electricity users in the remote villages have the potential of obtaining electricity through the main utility grid, while others can only get electricity by installing